Title: Lamb definition project

Key area 2: Assess the impact of extending the lamb definition on eating quality.

Paper prepared by:

David W Pethick
Project leader, Meat & Livestock Australia's sheepmeat eating quality program
20th May, 2008

Executive Summary

This paper is in response to the lamb definition project commissioned by Sheepmeat Council of Australia and the Australian Meat Industry Council. The paper is specifically focused on:

Key area 2: Assess the impact of extending the lamb definition on eating quality:

Part (a) Write a paper to:

- Summarise MSA Sheep science and research findings to date in relation to age/category and its impact on eating quality.
- Provide an indication of the extent of the impact on eating quality of older animals.

Part (b) Subject to the information from item (a), prepare a paper that outlines the capacity of the MSA Sheepmeat program to successfully underpin an extended definition of lamb.

1. Part (a) Effect of age on eating quality:

(i) Lamb (no permanent erupted teeth) eats better than hogget or young mutton (2-4 fully erupted permanent teeth) when assessed across the range of cuts in the carcase.

(ii) The leg cuts of hogget or young mutton are inferior on average to lamb by as much as 5-10 consumer points (on a scale of 0-100) with a typical value for lamb of 65 across a number of cut x cook combinations. The risk of consumers finding an unsatisfactory eating experience (failure) would increase from 5% in lamb to 10-15% in hoggets which equals a 2-3 times increase in failure risk.

(iii) The risk of hoggets under performing is greater when they are grown slowly and have low fat score (<6mm GR) and/or low intramuscular fat levels.

(iv) Hogget meat will always be detected as noticeably darker by consumers, when compared to lamb (due to higher myoglobin levels in muscle as animals age).

(v) From an eating quality point of view the current lamb definition used in Australia is supported. The evidence available suggests that any change in definition will increase the risk of product failure (as defined by the Eating Quality assessment system MSA), and that this risk is greater in animals that have not been managed under good growing conditions. It is reasonable to suggest that such animals are likely to be heavily represented in drafts sold as lamb under the proposed new definition but which had missed this classification under the current definition – thus effectively increasing the consumer perception risk for the industry.

(vi) However small changes in the dentition of lamb will have little effect on eating quality. Small change is defined for example as '1 or 2 permanent incisor(s) erupted but not in wear, as the time for freshly erupted permanent incisors to reach the height of the remaining 'milk teeth' is relatively short (30 days). This paper does not address the industry practicality of policing compliance with any such change in dentition.

(vii) A major change in the lamb definition is not supported. Major change is defined for example as fully erupted 2 permanent incisor teeth in wear.

2. Part (b) Capacity of the MSA Sheepmeat program to successfully underpin an extended definition of lamb:

All recommendations on animal age are based on an MSA pathway from production to consumption. This requires meeting the dentition definition, recommended growth rates, carcase and fat specifications, curfew and lairage times, pH x temperature window (i.e. electrical stimulation) and meat aging. Any move to change the lamb definition should be undertaken using a full MSA pathways approach to minimize additive effects from increasing the risk of product failure i.e. combined effects of older age specifications, poorly finished animals, no electrical stimulation and short meat aging would escalate the risk of product failure.

Background

There are a number of studies which show that sheep meat becomes tougher as the source animal becomes older. This is well accepted since connective tissue within muscle hardens due to more cross links being formed as animals age. However the magnitude of this effect is poorly defined for sheep meats, especially in the period where dentition changes from milk teeth to the eruption of permanent incisors. The conclusion from international research previous to that undertaken by the sheep meat eating quality program was that lamb be defined as 12 months or under in age in order to maximise consumer appeal (Jeremiah 2000).

Aims

This paper is in response to the lamb definition project commissioned by Sheepmeat Council of Australia and the Australian Meat Industry Council. The paper is specifically focused on:

Key area 2: Assess the impact of extending the lamb definition on eating quality:

Part (a) Write a paper to:

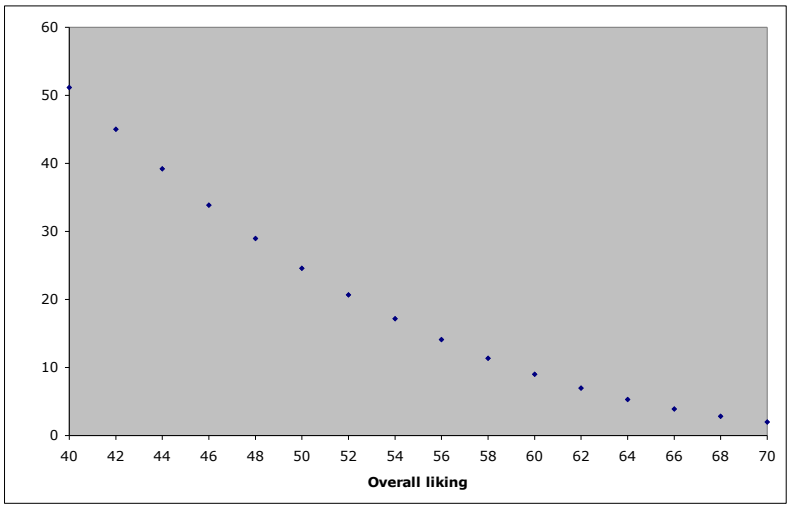
- Summarise MSA Sheep science and research findings to date in relation to age/category and its impact on eating quality.
- Provide an indication of the extent of the impact on eating quality of older animals.

Part (b) Subject to the information from item (a), prepare a paper that outlines the capacity of the MSA Sheepmeat program to successfully underpin an extended definition of lamb.

Consumer defined eating quality

A key feature of MSA research is to measure palatability using untrained consumers which means real estimates of eating quality are made. Consumers were asked to rate lamb and sheepmeat for tenderness, liking of flavour, juiciness and overall liking on a score from 0-100. The best predictor of consumer palatability is overall liking and this was explained by an equal weighting of tenderness, liking of flavour and juiciness. The consumers were also asked to rank the meat as unsatisfactory, good everyday, better than every day or premium. From these measurements, it was possible to compare the score for overall liking to the chance of meat being categorised as unsatisfactory (= fail). The analysis is shown below in Figure 1. The worst lamb cuts, grilled or roasted topsides, eat at a score of 50 of less and so have a ≥25% chance of being rated unsatisfactory – these cut x cook combinations are not recommended under MSA guidelines (Table 2) given the high chance of failure. The remainder of the cuts from a lamb carcase eat at a score of 60 or above and so we can underpin the eating quality of those lamb cuts at 10% failure or lower.

Figure 1. The relationship between consumer score for overall liking and the chance (%) of the meat being rated as unsatisfactory (fail).



Summary of animal age and eating quality experiments

1. SMEQ animal age experiment (Pethick et al. 2005)

Lamb (no erupted permanent incisors) was contrasted with hogget/young mutton (2 or 4 permanent erupted incisors) in 2 separate experiments (72 animals in total) designed as the major SMEQ 'animal age experiment'. All animal groups had grain assisted nutrition and were slaughtered using best practice MSA guidelines. In total 293 consumers assessed lamb or hogget and the results are summarised in Table 1. There was no difference in the eating quality of the grilled short loin but a clear effect for the topside and outside extracted from roasted easy carve legs to be tougher or less preferred (lower overall liking) in 2 and 4 tooth animals compared to the lambs. Averaged over both experiments, the overall liking for the leg cuts in lamb was 61 points and this declined to 54 in hoggets. Using Figure 1 the risk of consumers failing the product would increase from 8% in lamb to 17% in hogget, a greater than 2-fold increase in risk.

Conclusion: The leg cuts of lamb eat better than hogget, little difference in the loin.

Table 1. SMEQ animal age experiment

Expt 1 Merino lamb – 8.5mo, milk teeth, HCW 18kg, GR 8mm Merino hogget/mutton – 22mo, 2/4 teeth, HCW 25kg, GR 12mm		
	Lamb v hogget/mutton	
Cut	Tenderness	Overall liking
Short loin – grill	Not significant	Not significant
Outside – grill	Lamb significantly higher (4 points)	Not significant
Expt 2 1st cross lamb – 12mo, milk teeth, HCW 20.3, GR 10mm Merino hogget/mutton – 22mo, 2/4 teeth, HCW 20.3, GR 7mm		
	Lamb v hogget/mutton	
Cut	Tenderness	Overall liking
Short loin – grill	Not significant	Not significant
Easy carve leg roast (Topside/Outside tested)	Lamb significantly higher (11 points)	Lamb significantly higher (8 points)

Note – the probability values associated with the statistical significance are not included in the tables in this paper for simplicity of reading. The detailed data and analysis is available in Pethick et al. 2005.

2. Sheep CRC serial slaughter experiment (Hopkins et al. 2007)

A large serial slaughter experiment based on the major breeds and genotypes (using LAMBPLAN Australian sheep breeding values to sample the sires used) used in Australia to produce lamb has recently been undertaken. The genetic contrasts are shown below (sire x dam) with 4 sires per class producing 199 progeny per contrast.

Merino x Merino
Poll Dorset [high muscle ASBV] x Merino
Poll Dorset [high growth ASBV] x Merino
Poll Dorset [high growth ASBV] x Border Leicester/Merino
Border Leicester x Merino

The progeny were all run as a common mob and subsets of animals slaughtered at 4, 8, 14 and 22 months of age (16, 23, 33 and 42kg HCW respectively) using best practice MSA guidelines.

The shear force (a measure of tenderness) of the loin and topside were measured. The shear force of the loin was not influenced by age, but the topside was significantly tougher in all breeds/genotypes at 14 and 22 months of age by 1.2 and 1.9kg respectively. The magnitude of the shear force effect is highly consistent with the consumer eating quality estimates in the SMEQ animal age experiment described above.

The loin became darker (and more red) as animal age increased reaching a threshold where consumers could detect the colour differences around the eruption period (Hopkins et al. 2007, Weise et al. 2005).

Eruption of the first incisor was 31-65% complete at 14 months of age depending on the breed type. The average age of eruption of the first incisor was 427 days with a range of 369 - 483 days. There was a significant Border Leicester effect (either via the sire or dam) causing the first incisor to erupt 34 (±12) days earlier and ewes erupted 8 days later than wethers. There were no other significant effects on dentition category.

In related CRC studies it was concluded that the USDA system of estimating ossification at the metacarpal breakjoint is fundamentally flawed as a reliable predictor of animal age or maturity, due to the greater variability and gender/genotype divergence of metacarpal bone growth compared to the major long bones (Cake et al. 2006). Indeed the most accurate estimate of animal age was the weight of the eye lens.

Conclusion: The leg cuts of lamb are more tender than hogget; lamb is lighter in colour than hogget

3. SMEQ commercial cuts (Pethick et al. 2006)

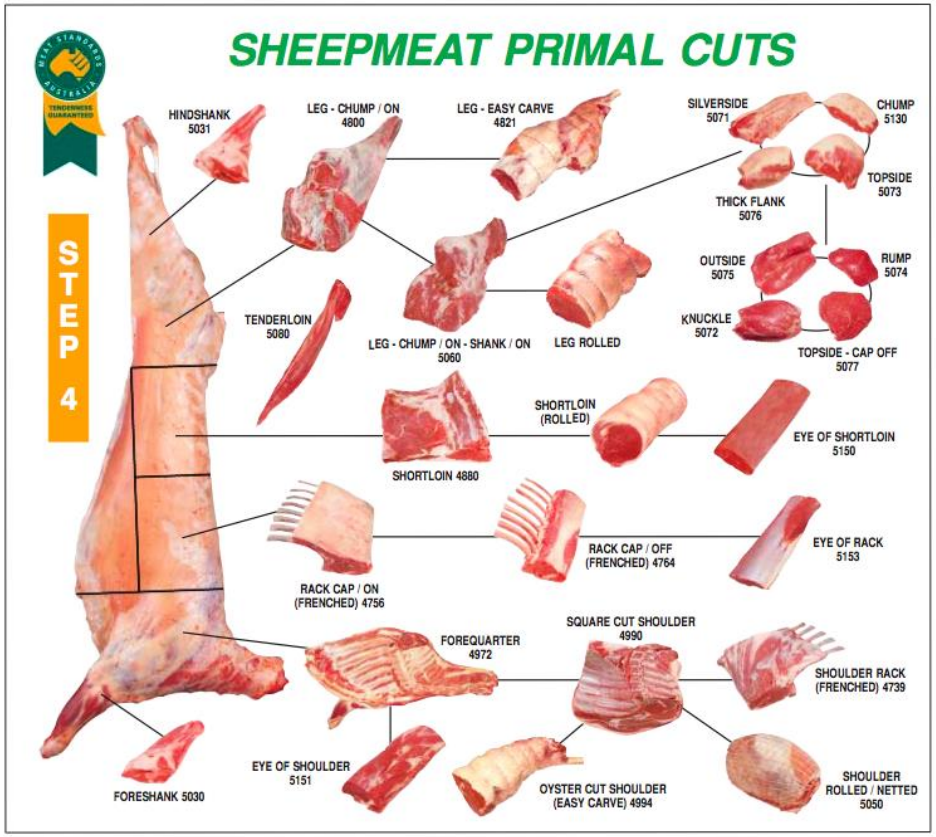
Lambs (56, 2nd cross, no erupted incisors), hoggets (47, Merino, 2 teeth)/young mutton (9, Merino, 4 teeth) and old ewe mutton (56 Merino, full/broken mouth) were managed as one group on a grain assisted diet and slaughtered using best practice MSA guidelines. The lambs (19.9kg HCW, 13mm GR) and hoggets/young mutton (20.6kg HCW, 10mm) had similar carcase specifications. This experiment was more focused on understanding cuts rather than animal age since not all cuts could be obtained from each carcase – there were only 12 'animal' replications per cut x cook cell. That is for any cut x cook combination, only 12 lambs were compared to 12 hoggets/young mutton. In total 1,267 consumers tested lamb or hogget. There was no overall significant difference between the eating quality of lamb versus hogget meat in this experiment. However there was a consistently lower score (5-10 consumer points) for overall liking especially for the leg cuts obtained from the hogget (Table 2) consistent with the previous research.

Now to summarise all the consumer work on lamb versus hogget to date. The leg cut x cook combinations for lamb carcases have an average overall liking score of 65 points (range 60-70) and this represents a 5% chance of failure (Figure 1). The decline in the score for cuts from hoggets is in the range of 5-10 consumer points meaning an increase in the risk of failure from 5% to 10-15%. That is the leg cuts of hogget have a 2-3 times increase in failure rate.

Conclusion: The leg cuts of lamb eats better than hogget, little difference in the loin.

Table 2. Commercial cuts eating quality summary (5 = excellent, 4 good, 3 average)

MEAT STANDARDS AUSTRALIA



QUALITY GRADE BY COOKING METHOD

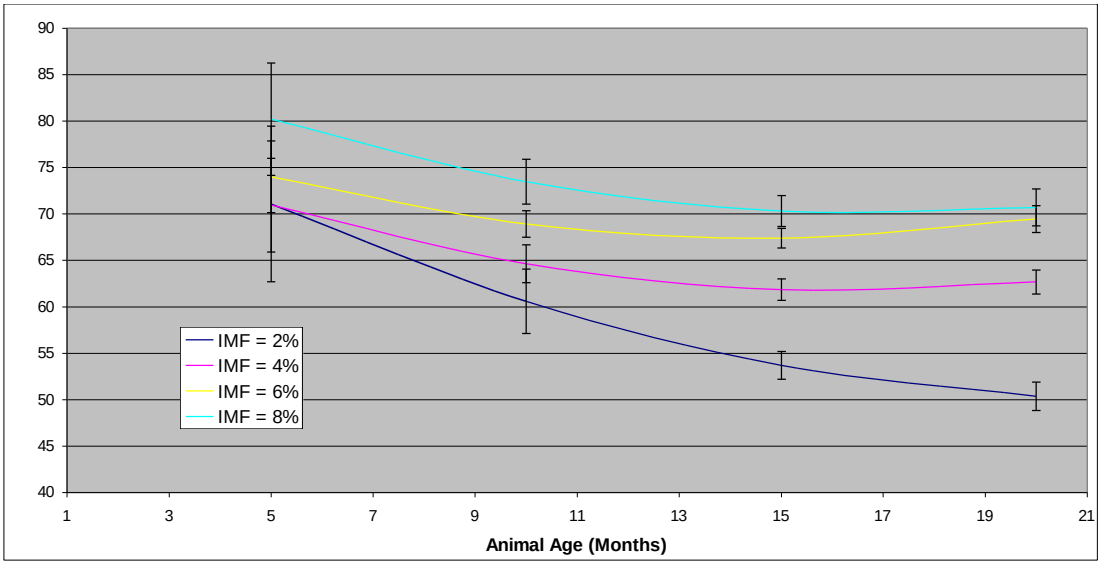
	LAMB (L)	HOGGET (H)	MUTTON (M)		
CUT	HAM	GRILL	ROAST	STIR FRY	C/ROLE
Leg Chump / On	4800		4 4		
Leg 'Easy Carve'	4821		4 3		
Leg Chump / Off	4820		4 4		
Chump	4790		4 4		
Chop		5 4 3			
Hind Shank	5031				3 3
Leg Chump / On (Boneless)	5060		4 4		
Rolled / Tied			4 4		
Topside	5073			4 3	
Silverside	5071			4 4 3	
Thick Flank (Round)	5076	4 4	3 3	4 4	
Chump (Rump)	5130	5 4	4 4	4 4	4 4
Topside (Den)	5077			4 3	
Outside (Den)	5075			4 3 3	
Knuckle (Round)	5072	4 4	3 3	4 4 3	
Rump (Den)	5074	5 4 3	4 4 3	4 4	4 4
Loin	4860		5 4 4		
Shortloin	4880		5 4 4		
Rolled			5 4 4		
Noisettes		4 4 3	5 4 4		
Chop		5 4 3			
Eye of Shortloin	5150	4 4 3		4 4 4	
Rack	4932		5 5 3		
Rack Cap / On (Frenched)	4756		5 5 3		
Cutlet		5 5 3			
Rack Cap / Off (Frenched)	4764		5 5 4		
Cutlet		5 5 3			
Backstrap	5109	4 4 3		4 4 4	
Eye of Rack	5153	4 4 3		4 4 4	
Forequarter	4972		4 3		
Square Cut Shoulder	4990		4 3		
Chop		4 3			
Shoulder Rack (Frenched)	4739		4 3		
Cutlet		4 3			
Fore Shank	5030				3
Oyster Cut Shoulder	4980		4 3		
Shoulder (Easy Carve)	4994		4 3		
Forequarter (Boneless)	5047		4 3		
Shoulder Rolled/Netted	5050		4 3		
Neck Fillet Roast	5039		4 3		
Eye of Shoulder	5151		4 3		
Tenderloin	5080	5 5 5			
Butt Tenderloin	5081	5 5 5			
Tenderloin / Butt Off	5082	5 5 5			
Breast & Flap	5010	No recommended cooking methods			
Neck	5020				
Spare Ribs	5015				

4. Overall analysis of IMF, loin eating quality and sheep age

Intramuscular fat (IMF) plays a role in the overall liking of lamb meat (Pethick et al. 2007) and is ideally in the range of 4-5% as a minimum threshold to underpin lamb juiciness and liking of flavour. A data set was developed from MSA lamb and sheepmeat research where IMF and consumer eating quality of the grilled short loin were measured in lambs and hoggets (485 animals). As lamb gets older and becomes hogget (approximately 14 months of age) there is a significant trend for adequate IMF levels (4-5%) to become more important (Figure 2). Thus grilled short loins with only 2-3% IMF showed an increased risk of under performing (i.e. consumer score <65 points) especially when animals reach 14 months or older. Low IMF levels (i.e. 2-3%) are most likely to occur in slowly grown and poorly finished hoggets (Thompson et al. 2008).

Conclusion: Poorly grown and finished hoggets have a higher risk of lower eating quality due to low IMF

Figure 2. Relational between animal age, intramuscular fat and overall liking score of the grilled short loin in lamb and hogget.



5. Teeth eruption (Weise et al. 2005)

An experiment was undertaken early in the MSA lamb and sheep research to investigate the eating quality of the loin around the eruption period. There was no effect of teeth eruption (no teeth erupted, partially erupted versus fully erupted but not in wear) on the eating quality of the grilled short loin, which is not surprising given the other results described in this paper because the loin muscle is the least influenced by animal age.

This work also showed that the time from initial eruption to the permanent incisors reaching the same level as the remaining lambs' teeth (i.e. 2 teeth but not in wear) averaged about 4 weeks (Table 3) with a range of 1 – 8 weeks.

Conclusion: the eating quality of the loin is relatively insensitive to animal age

Table 3. The number of days between partial teeth eruption and full teeth eruption detected in young Merino, first cross and second sheep

	Merino	First cross	Second cross	SEM
Mean	30.4	23.4	29.0	2.20
Minimum	9	11	10	
Maximum	48	56	56	

Capacity of the MSA Sheepmeat program to successfully underpin an extended definition of lamb:

All recommendations on animal age are based on an MSA pathway from production to consumption. This requires meeting the dentition definition, recommended growth rates, carcase and fat specifications, curfew and lairage times, pH x temperature windows (i.e. electrical stimulation) and meat aging (Appendix 1). Any move to change the lamb definition should be undertaken using a full MSA pathways approach to minimize additive effects from increasing the risk of product failure i.e. combined effects of older age specifications, poorly finished animals, no electrical stimulation and short meat aging would escalate the risk of product failure.

Conclusions

1. Part (a) Effect of age on eating quality:

(i) Lamb (no permanent erupted teeth) eats better than hogget or young mutton (2-4 fully erupted permanent teeth) when assessed across the range of cuts in the carcase.

(ii) The leg cuts of hogget or young mutton are inferior on average to lamb by as much as 5-10 consumer points (on a scale of 0-100) with a typical value for lamb of 65 across a number of cut x cook combinations. The risk of consumers finding an unsatisfactory eating experience (failure) would increase from 5% in lamb to 10-15% in hoggets which equals a 2-3 times increase in failure risk.

(iii) The risk of hoggets under performing is greater when they are grown slowly and have low fat score (<6mm GR) and/or low intramuscular fat levels.

(iv) Hogget meat will always be detected as noticeably darker by consumers, when compared to lamb (due to higher myoglobin levels in muscle as animals age).

(v) From an eating quality point of view the current lamb definition used in Australia is supported. The evidence available suggests that any change in definition will increase the risk of product failure (as defined by the Eating Quality assessment system MSA), and that this risk is greater in animals that have not been managed under good growing conditions. It is reasonable to suggest that such animals are likely to be heavily represented in drafts sold as lamb under the proposed new definition but which had missed this classification under the current definition – thus effectively increasing the consumer perception risk for the industry.

(vi) However small changes in the dentition of lamb will have little effect on eating quality. Small change is defined for example as '1 or 2 permanent incisor(s) erupted but not in wear, as the time for freshly erupted permanent incisors to reach the height of the remaining 'milk teeth' is relatively short (30 days). This paper does not address the industry practicality of policing compliance with any such change in dentition.

(vii) A major change in the lamb definition is not supported. Major change is defined for example as fully erupted 2 permanent incisor teeth in wear.

2. Part (b) Capacity of the MSA Sheepmeat program to successfully underpin an extended definition of lamb:

All recommendations on animal age are based on an MSA pathway from production to consumption. This requires meeting the dentition definition, recommended growth rates, carcase and fat specifications, curfew and lairage times, pH x temperature window (i.e. electrical stimulation) and meat aging. Any move to change the lamb definition should be undertaken using a full MSA pathways approach to minimize additive effects from increasing the risk of product failure i.e. combined effects of older age specifications, poorly finished animals, no electrical stimulation and short meat aging would escalate the risk of product failure.

References

Cake, M.A., Gardner, G.E., Boyce, M.D., Loader, D and D.W. Pethick (2006) Forelimb bone growth and mineral maturation as potential indices of skeletal maturity in sheep. *Australian Journal of Experimental Agriculture,* 57, 699-706.

Hopkins, D.L., Stanley, D.F., Martin, L.C. and A.R. Gilmore (2007) Genotypic and age effects on sheep meat production 2. Meat quality. *Australian Journal of Experimental Agriculture,* 47, 1155-1164.

Hopkins, D.L., Stanley, D.F., Martin, L.C., Toohey, E.S. and A.R. Gilmore (2007) Genotypic and age effects on sheep meat production 1. Production and growth. *Australian Journal of Experimental Agriculture,* 47, 1119-1127.

Jeremiah LE (2000) The effects of chronological age, slaughter weight, and gender on lamb: a review. Technical Bulletin 2000-1E pp1-19. (Agriculture and Agri-Food Canada)

Pethick,D.W., D. L. Hopkins, D. N. D'Souza, J. M. Thompson, P. J. Walker (2005) Effect of animal age on the eating quality of sheep meat. *Australian Journal of Experimental Agriculture,* 45, 491-498.

Pethick, D.W., Pleasants, A.B., Gee, A.M., Hopkins, D.L. and I.R. Ross (2006) Eating quality of commercial meat cuts from Australian lambs and sheep. *Proceedings of the New Zealand Society of Animal Production* 66, 363-367.

Pethick DW, Barendse W., Hocquette J.F., Thompson J.M. and Y.H. Wang (2007) Marbling biology - growth & development, gene markers and nutritional biochemistry. In Energy and protein metabolism and Nutrition. EAAP publication No. 124 pp 75-88. Ed. I. Ortigues-Marty, Wageningen Academic Publishers.

Thompson, J.M., Gardner, G.E., Thomspon, K.E. and P. Allingham (2008) The effect of muscling EBV's on sheep meat eating quality. Final report SMEQ.045, Meat & Livestock Australia

Wiese, S.C., D. W. Pethick, J. T. B. Milton, R. H. Davidson, B. L. McIntyre, D. N. D'Souza (2005) Effect of teeth eruption on growth performance and meat quality in young sheep. *Australian Journal of Experimental Agriculture,* 45, 509-515.

Appendix 1. Summary of MSA Lamb and Sheepmeats pathways

MEAT STANDARDS AUSTRALIA

SHEEPMEAT PROCESSING GUIDE

MINIMUM REQUIREMENTS

STEP 1

RECOMMENDED GROWTH RATES

- 1st and 2nd cross - a minimum of 100grams/day for 2 weeks prior to consignment.
- Greater than 50% **Merinos** and **pure Merinos** at least 150grams/day for 2 weeks prior to consignment.

SUPPLY METHODS

- Direct consignment - All categories eligible.
- Saleyards - 1st and 2nd cross accepted through saleyards.
- Greater than 50% **Merinos** or **pure Merinos** accepted through saleyards providing processor can demonstrate that animals through this pathway meet pH/temp window requirements and pHu requirements as outlined in MSA Sheepmeat Standards Manual.

PRE - SLAUGHTER

- Minimum 2 weeks off shears (wool length ≥ 5mm).
- Fat score ≥ 2.
- HSCW ≥ 16kg for sucker (milk fed lamb), HSCW ≥ 18kg for all weaned lambs, hogget and mutton.
- Total time off feed not greater than **48 hours before slaughter**.
- Animals to have access to water at all times while not in transit.
- Minimum of 2 weeks at consignment property before dispatch.
- Maximum time in transit 24hrs.
- National Vendor Declaration (Sheep and Lambs) and Waybill to be correctly filled out and accompany consignment to saleyards or processor.

PROCESSING

- AUS-MEAT accreditation.
- Time spent in lairage yards at processing plant to be not greater than 24 hours with access to water.
- If livestock are held over in a holding paddock and fed at the processing plant, the processor must demonstrate that animals through this pathway meet pH/temp window requirements and pHu requirements as outlined in MSA Sheepmeat Standards Manual.
- Head only electrical stunning.
- No sick or injured animals to be included.
- Excessively damaged carcases to be excluded (eg leg removed from carcase).
- Maintain Carcase identification.

CARCASE FAT CLASS

STEP 2

CARCASE SPECIFICATIONS

Category / Cipher	HSCW	Fat Score	GR
Lamb (Milk fed) as declared on NVD or **Young Lamb * YL ***	≥ 16kg	≥ 2	≥ 6mm
Lamb * L *	≥ 18kg	≥ 2	≥ 6mm
Hogget * H *	≥ 18kg	≥ 2	≥ 6mm
Mutton * M *, * W *, * E *	≥ 18kg	≥ 2	≥ 6mm

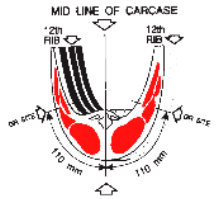
pH Temperature Window and Hang Options

Hang Method	Temperature @ pH 6	Minimum ageing before: (consumption/display/sale)
AT	18-25°C	5 days
AT	8-18°C	10 days
TS	8-35°C	5 days

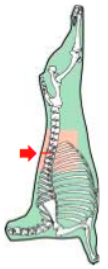
STEP 3

REFER: SHEEPMEAT PRIMAL CUTS CHART

GR MEASUREMENT SITE



The class is determined on the depth of tissue at the GR SITE. This site is located over the 12th rib, 110mm from the midline as shown in the diagram.



BASIC CATEGORY

DENTITION	DESCRIPTION	CATEGORY/CIPHER
0	**LAMB - female, castrate or entire male** animal that: ◆ Has 0 permanent incisor teeth. ◆ Milk Fed Lamb (Symbol 'MF'): Lamb that has not been weaned. Younger than 8 weeks.	**LAMB * L *** * 12 months (approx.)
1 - 8	**MUTTON - female or castrate male** animal that: ◆ Has at least one (1) permanent incisor tooth. ◆ In male has no evidence of Secondary Sexual Characteristics (SSC).	**MUTTON * M *** * Over 10 months

ALTERNATIVE CATEGORY

DENTITION	DESCRIPTION	CATEGORY/CIPHER
0	Carcase derived from **female or castrate male** ovine that: ◆ Has 0 permanent incisor teeth (in addition). ◆ Has no eruption of permanent upper molar teeth.	**YOUNG LAMB * YL *** * Up to 5 months only
1 - 2	Carcase derived from **female or castrate male** ovine that: ◆ Has 1 but no more than 2 permanent incisor teeth. ◆ In male has no evidence of Secondary Sexual Characteristics (SSC).	**HOGGET * H *** or **YEARLING MUTTON** * 10 to 18 months
1 - 8	Carcase derived from **female** ovine that: ◆ Has 1 or more permanent incisor teeth.	**EWE MUTTON * E *** * Over 10 months
1 - 8	Carcase derived from **castrate male** ovine that: ◆ Has 1 or more permanent incisor teeth. ◆ Has no evidence of Secondary Sexual Characteristics (SSC).	**WETHER MUTTON * W *** * Over 10 months

** Chronological age as shown is approximate only*